Comparison of CAM5.3 and CSRM over the ocean

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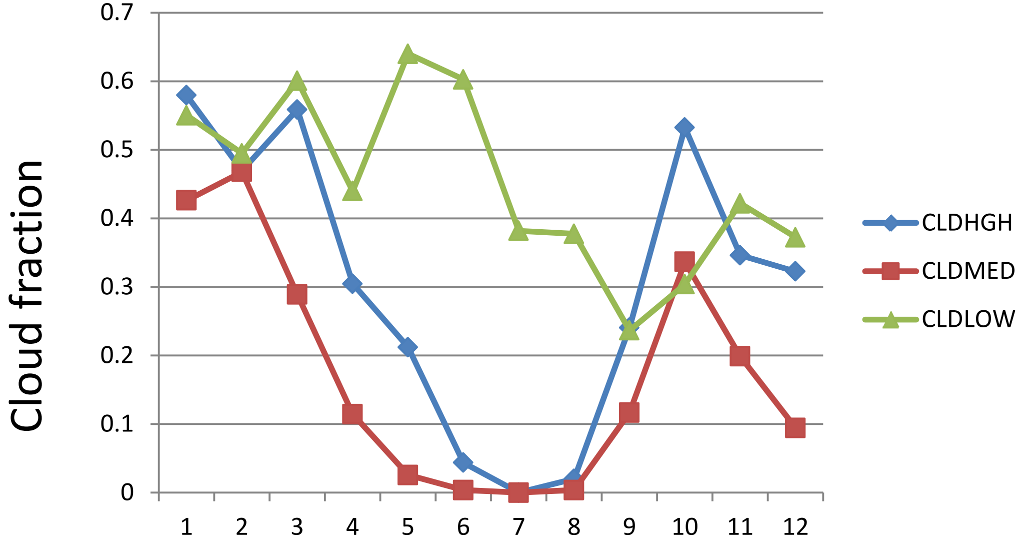
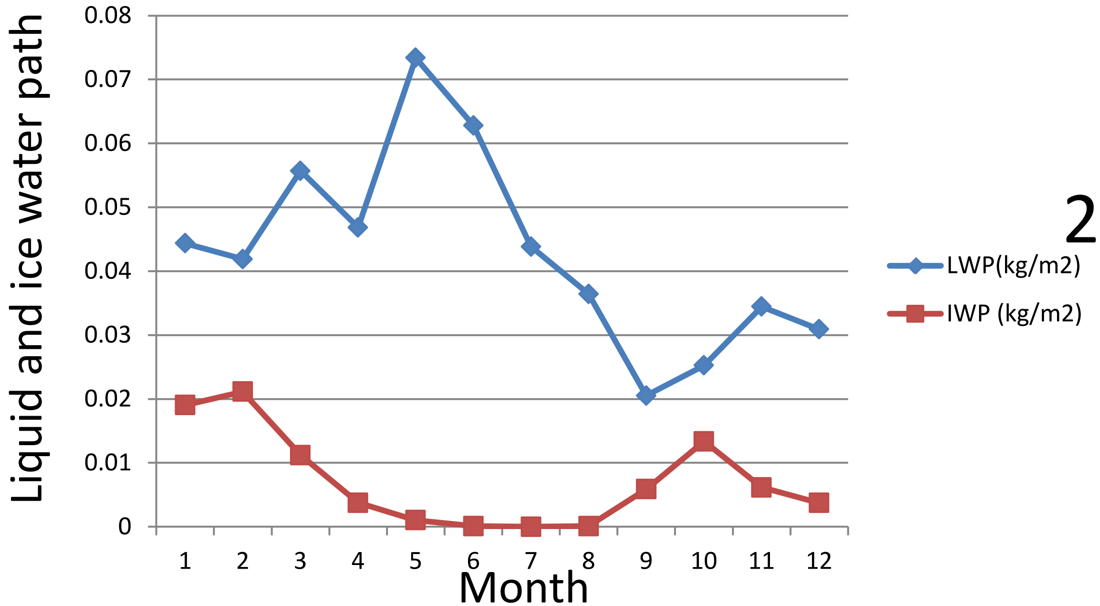
Methodology

1. We use CAM5.3 to generate the initial conditions and large-scale forcings at Azores in July.
2. We then integrate the NASA Goddard Cumulus Ensemble (GCE) model using the initial condition and forcings for 3 weeks.
3. Compare clouds from the two models.

Climatology at Azores: Seasonal cycle of cloud and liquid water path simulated by CAM5

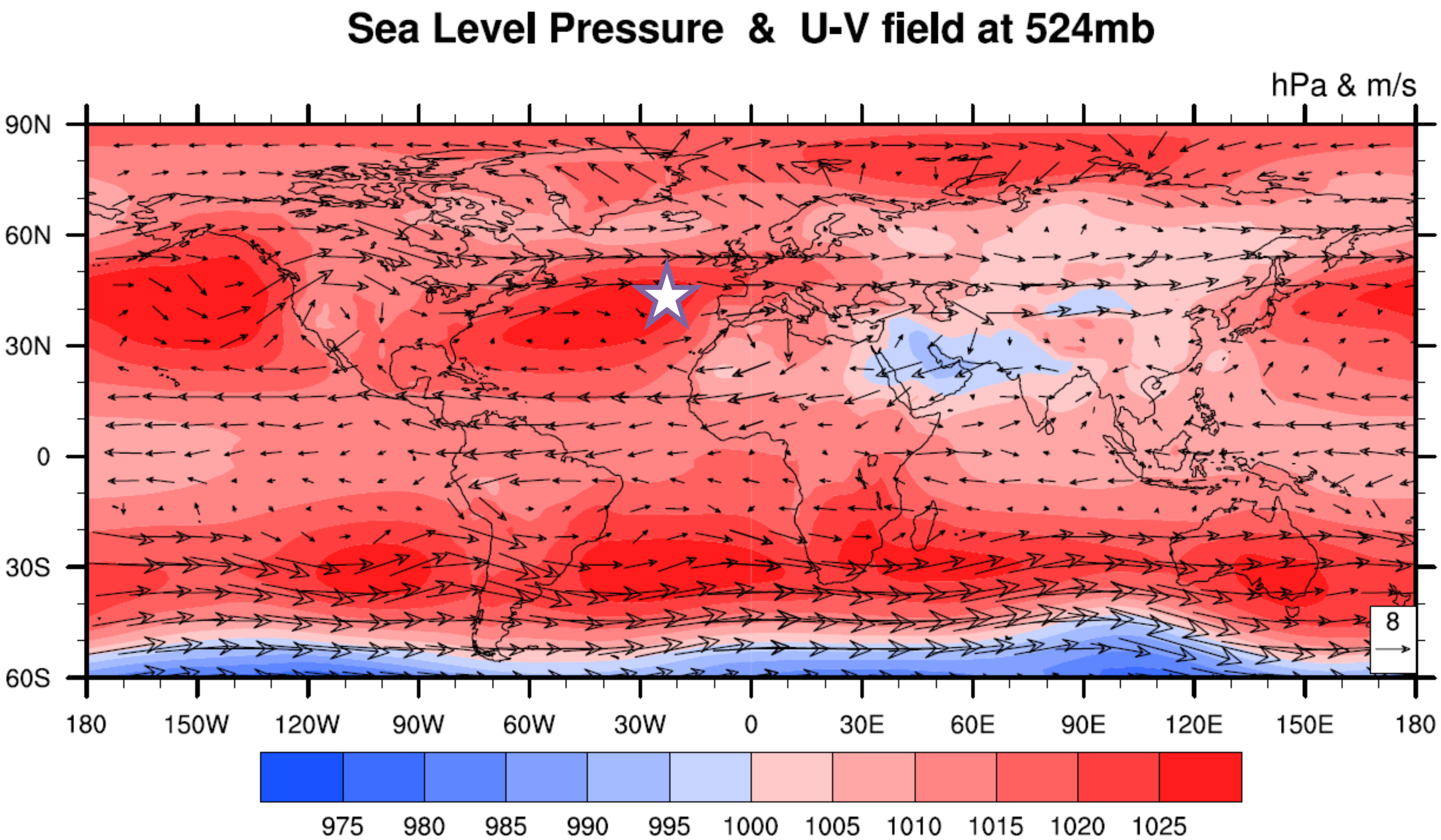




1. Lowest medium/high clouds coverage in July

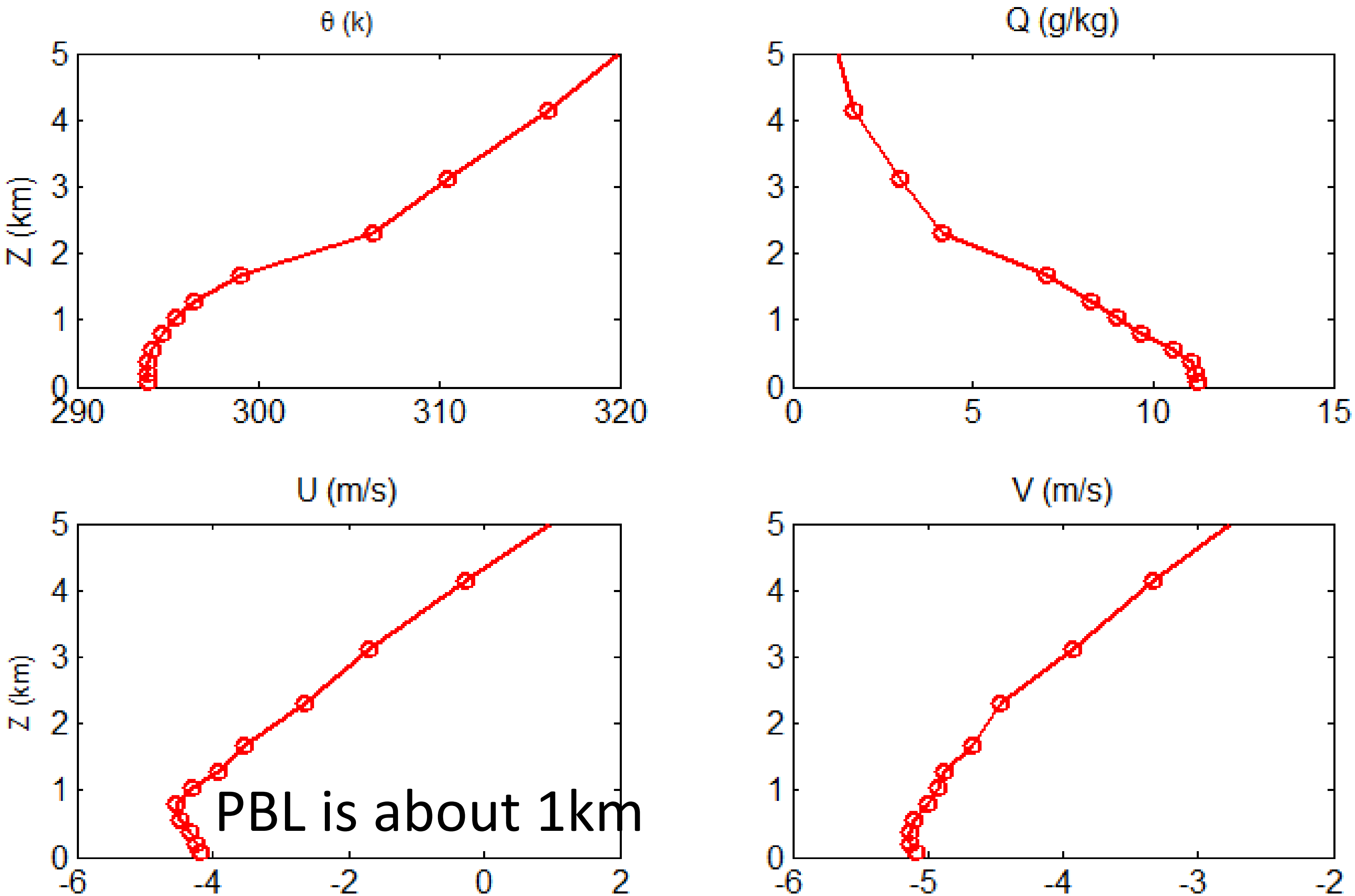
2. No ice in July.

Climatology at Azores: July condition

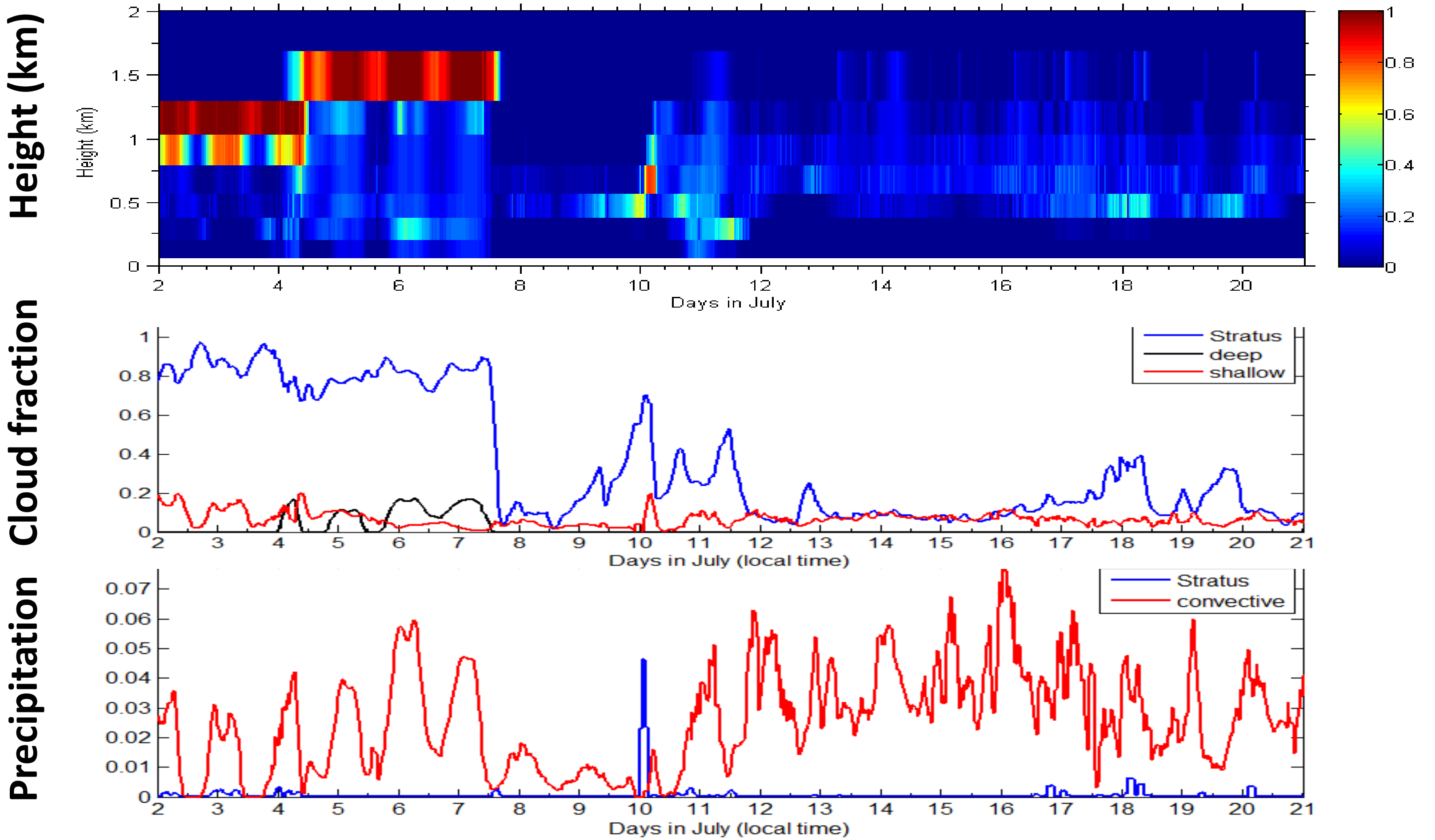


Azores is controlled by anticyclone high pressure in July.

Mean state from CAM5 in July

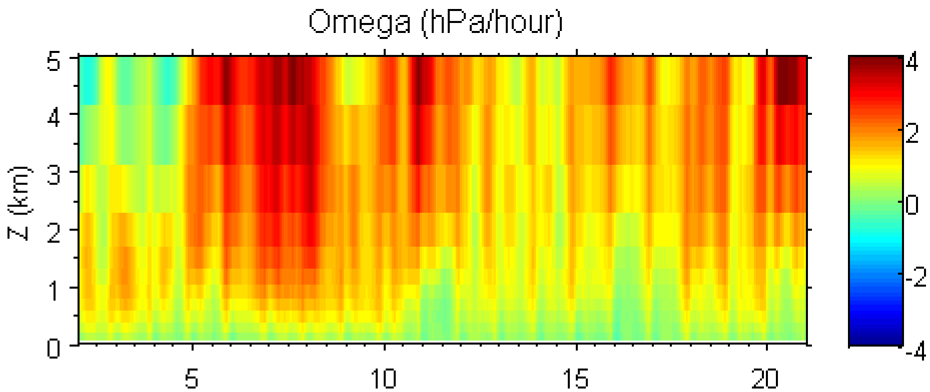


Day to day cloud fractions in July

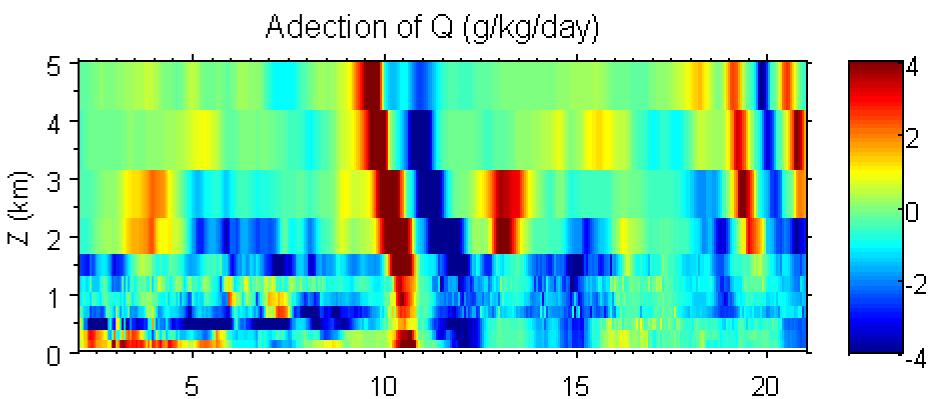


1. Stratus is dominant in the total cloud fraction.
2. However, no (almost) precipitation from stratus reaches to the ground.

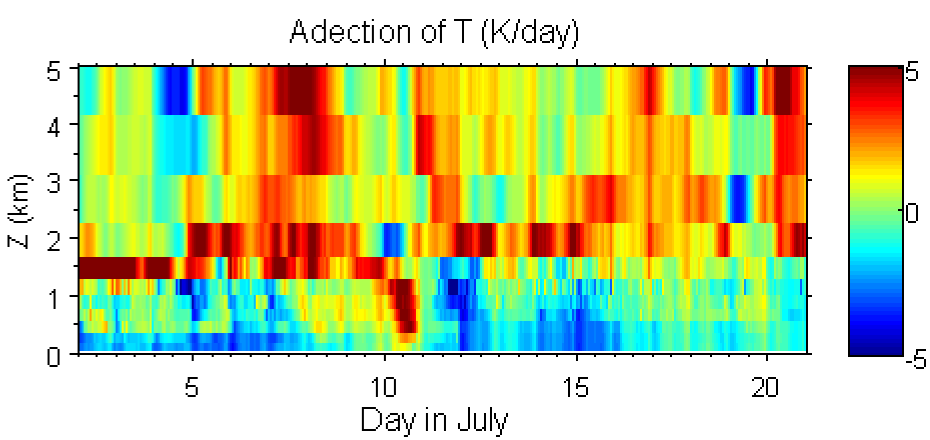
Forcings to drive CSRM -1



Omega (hPa/hour)

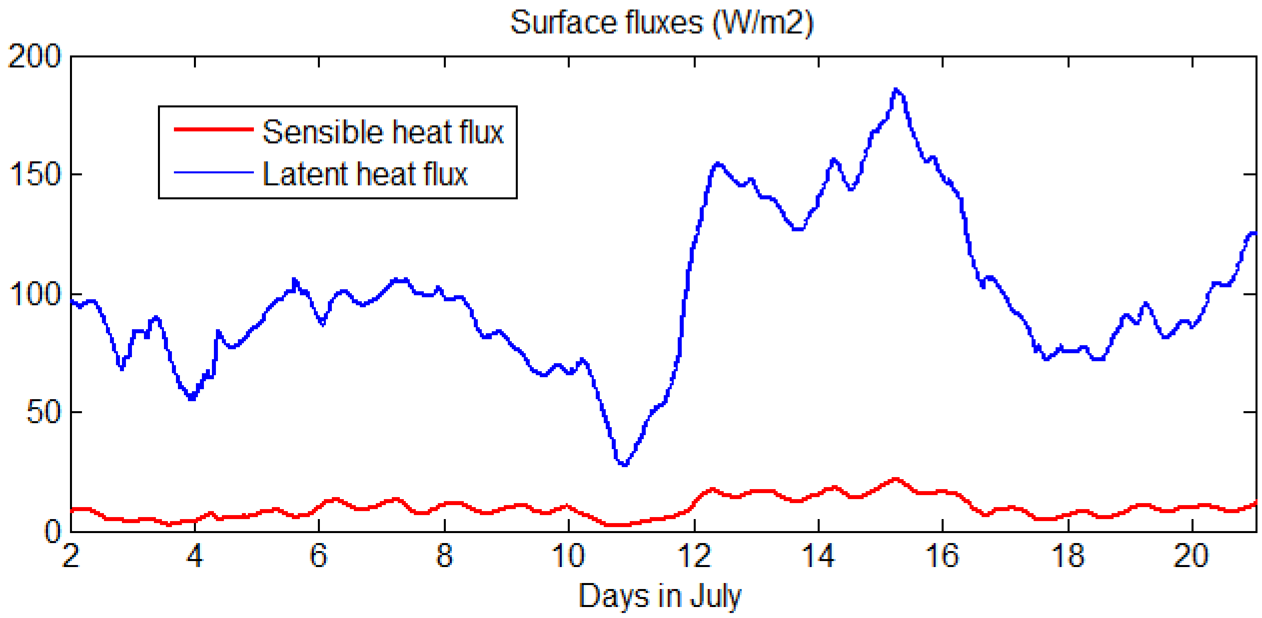


1. Advection (horizontal + vertical) of q



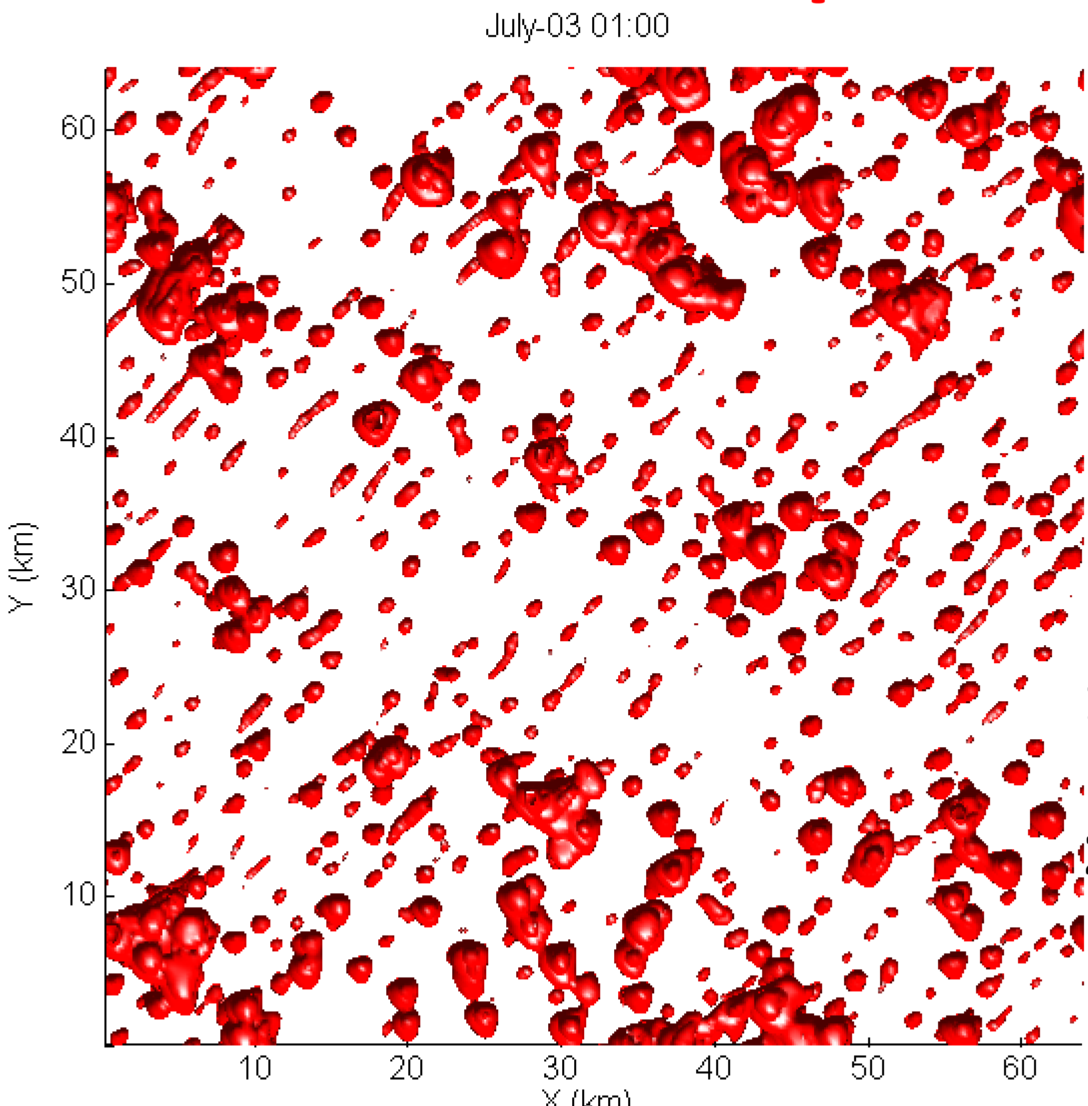
2. Advection (horizontal + vertical) of T

Forcings to drive CSRM -2



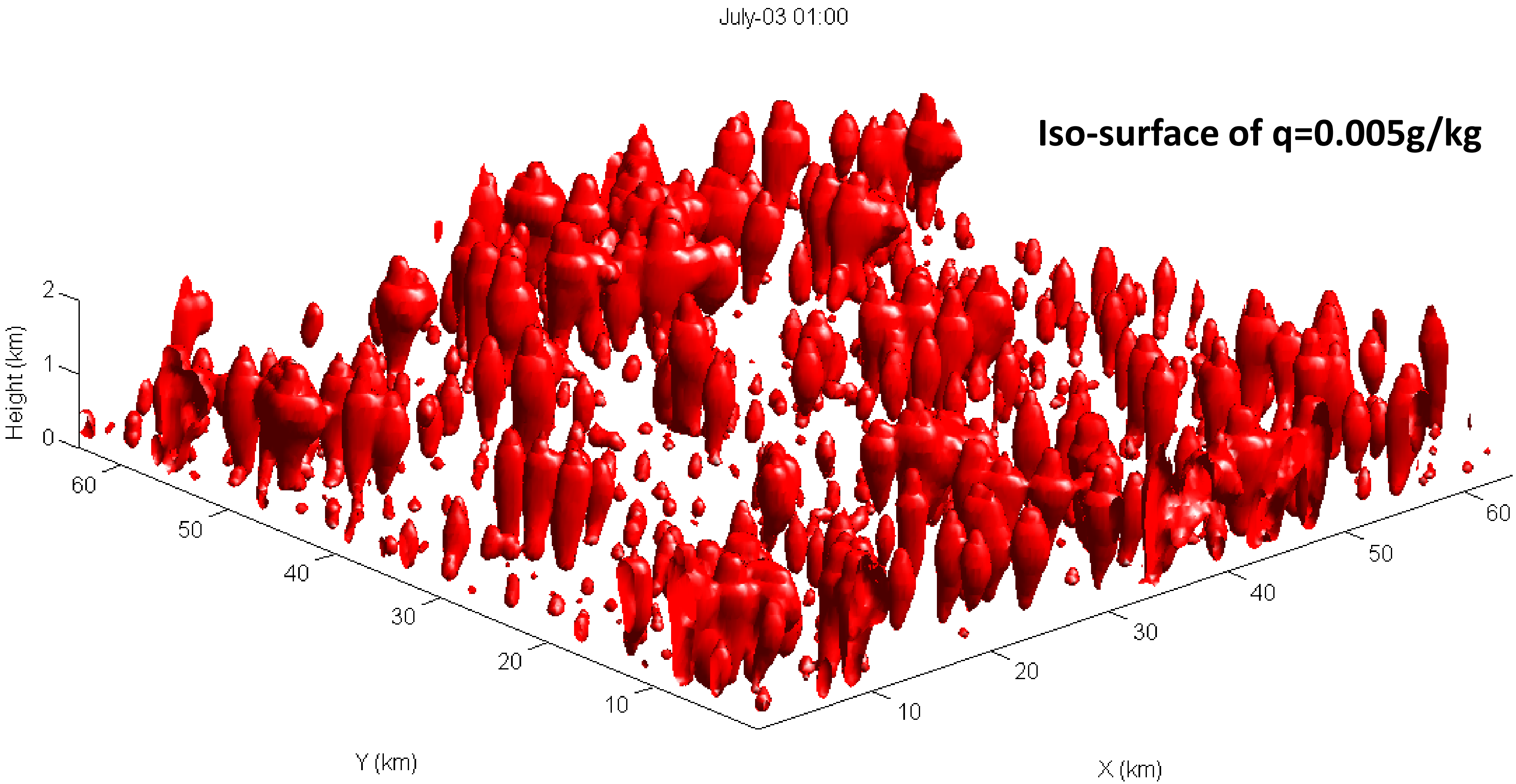
3. Surface sensible heat flux
4. Surface latent heat flux

Results: A typical view of the clouds- top view



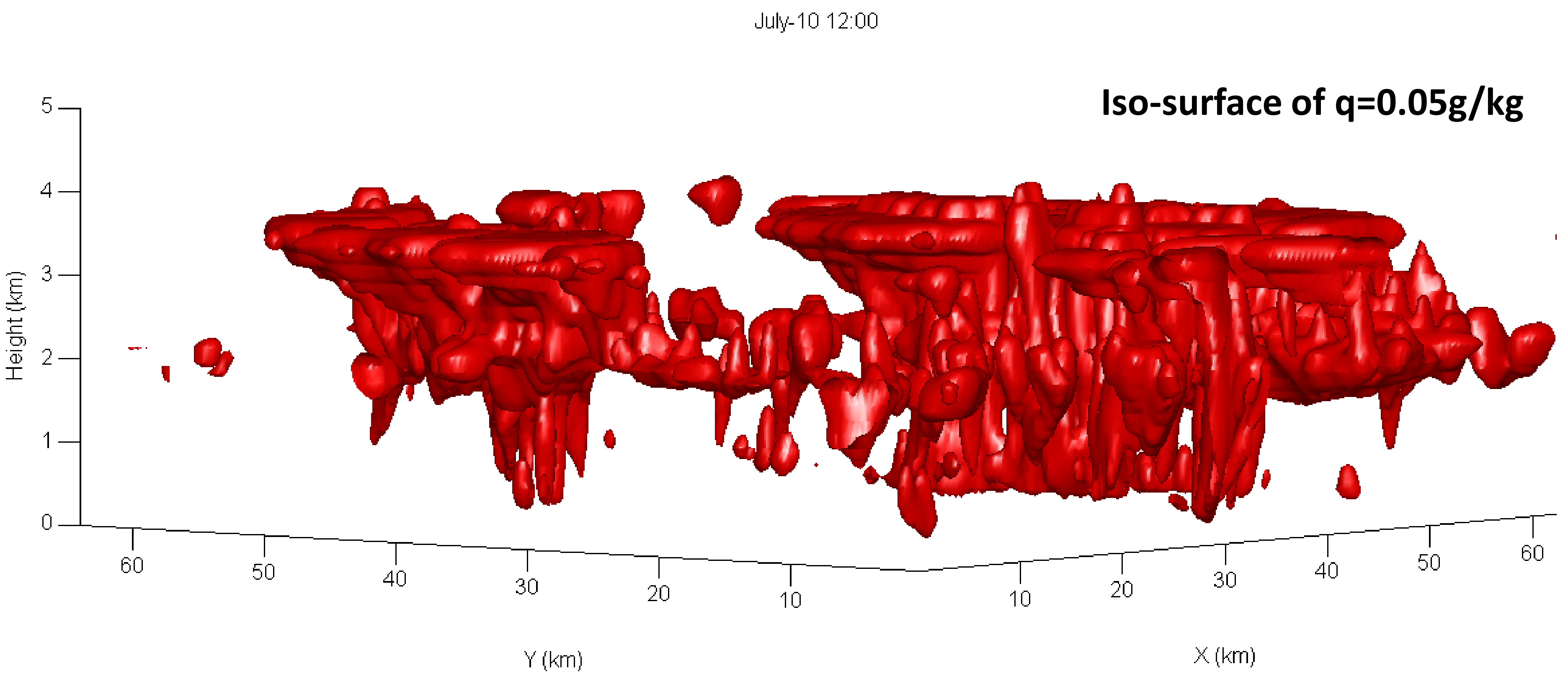
1. Iso-surface of q=0.005g/kg
2. Cloud fraction is ~20% to ~60%

A typical view of the clouds- side view



Clouds are below 2km.

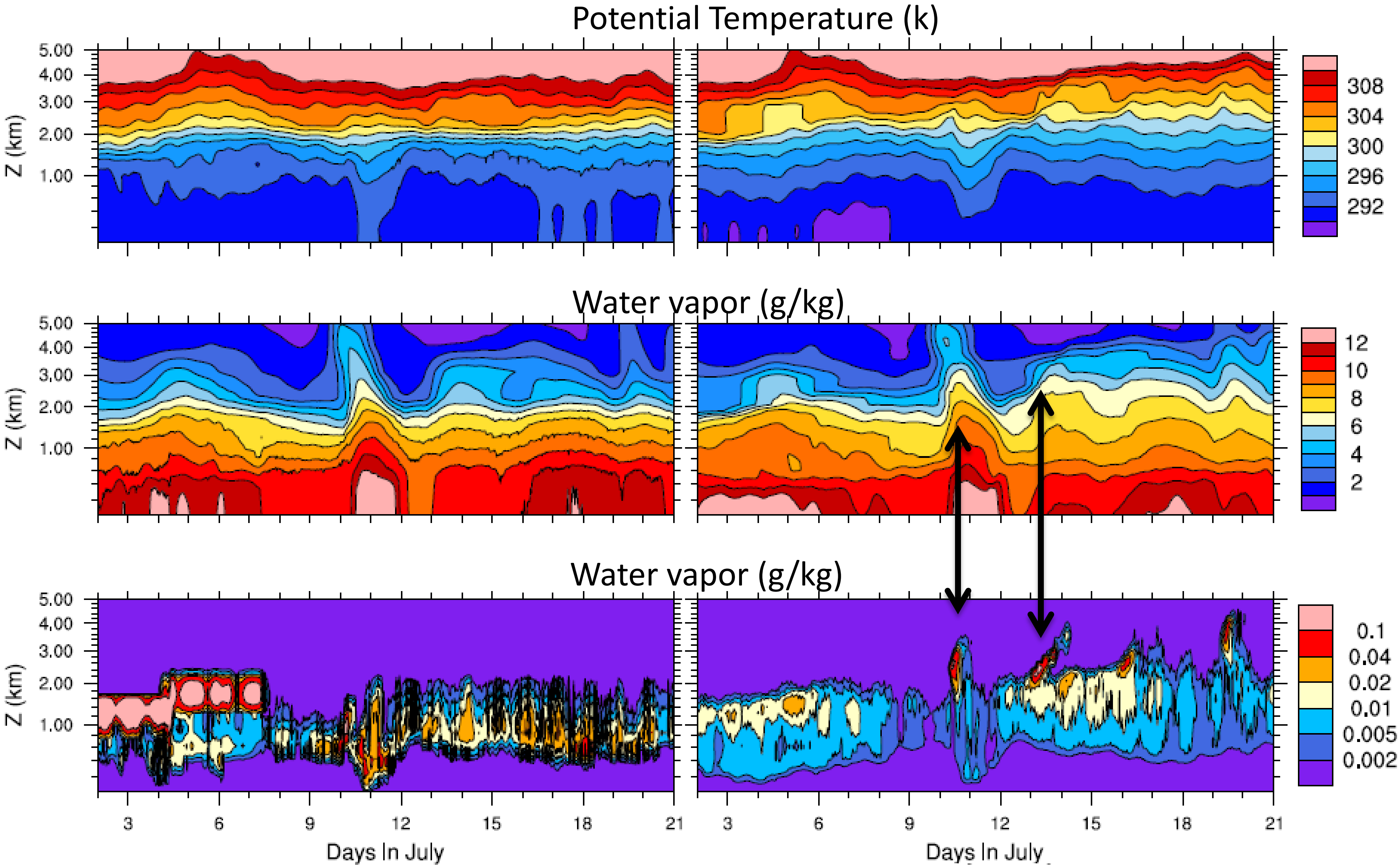
A view for cumulus with detrainment



1. Middle clouds developed with large advection of water vapor.
2. Cloud top can reach 4km

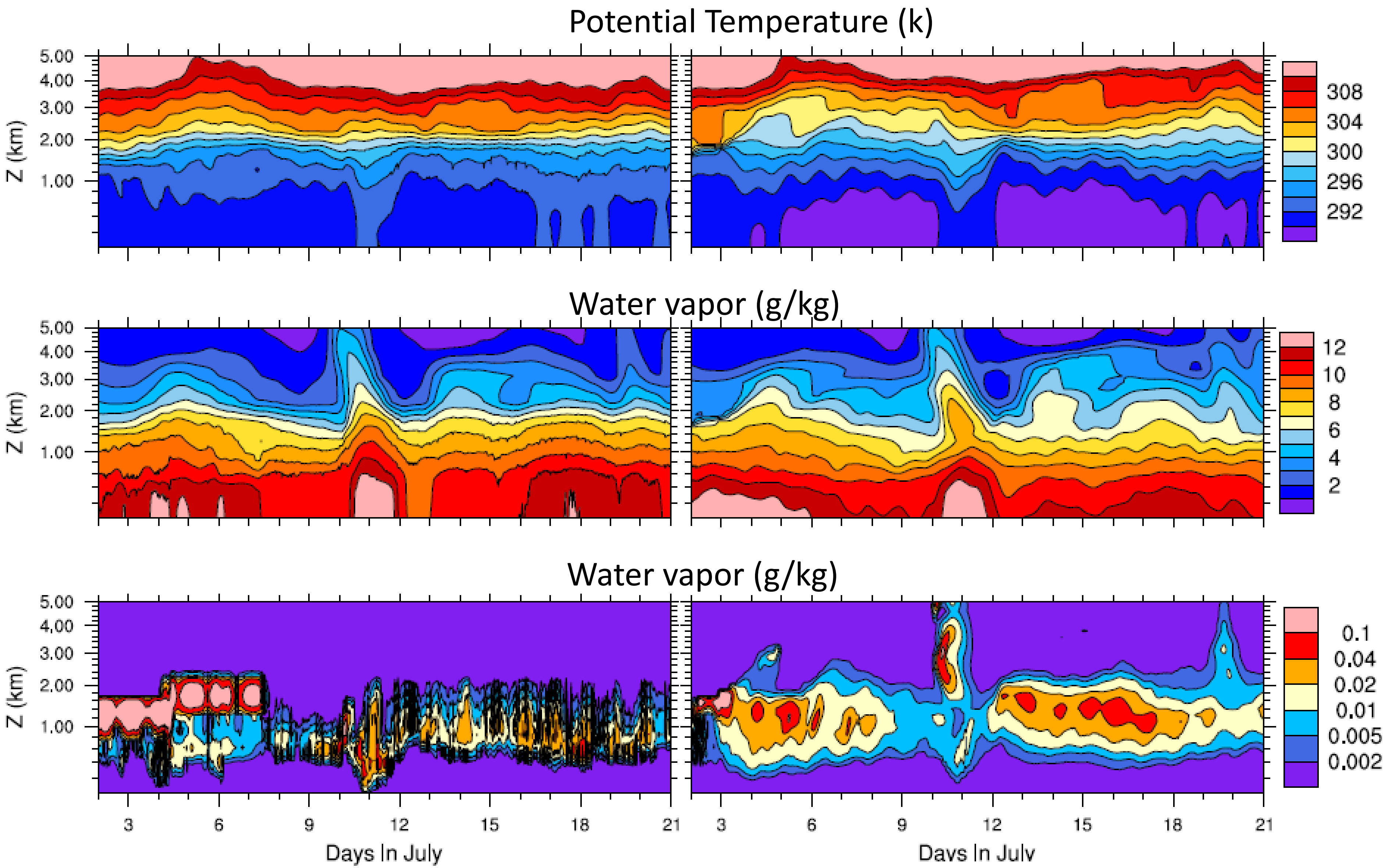
Height-Time plot of mean state

CAM5 vs. CSRM w/ dx=250m



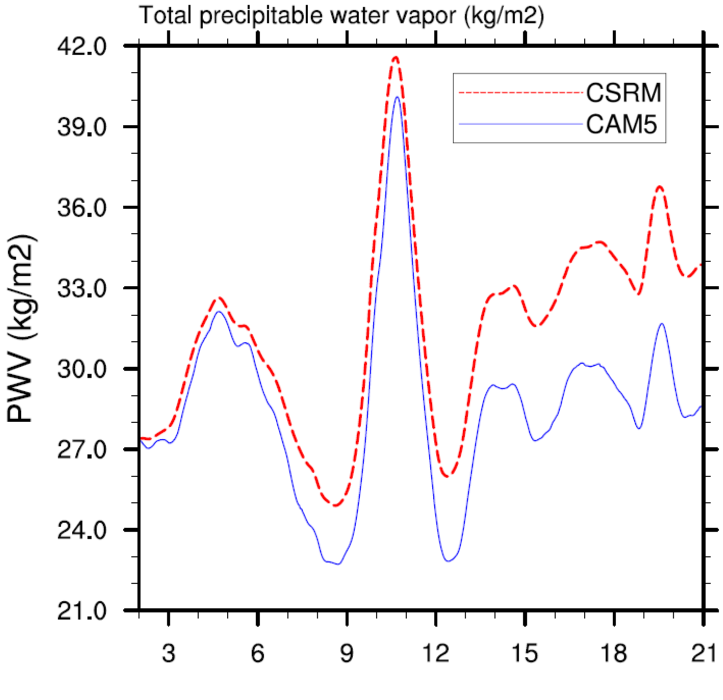
Height-Time plot of mean state

CAM5 vs. CSRM w/ dx=50km

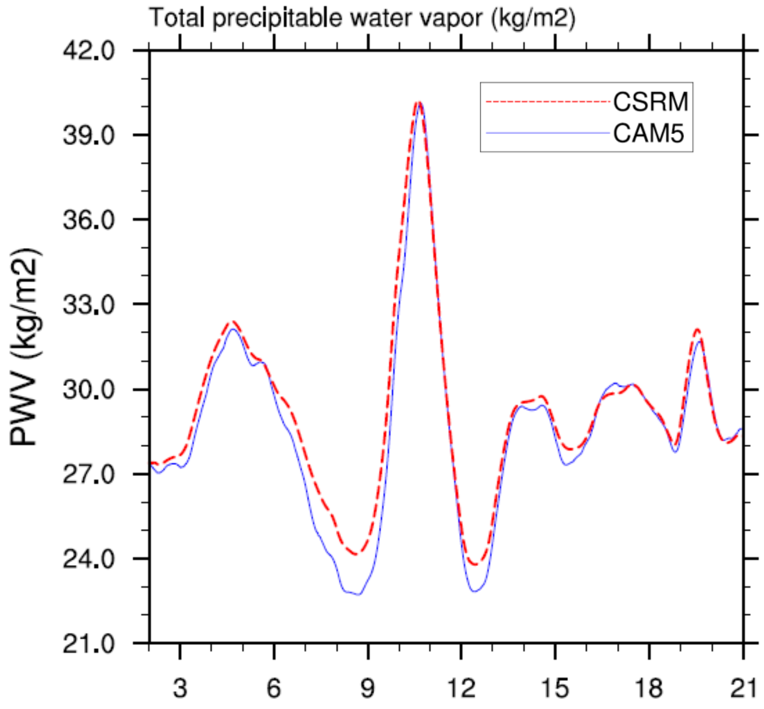


Effect of dx on total precipitable water

DX=250m

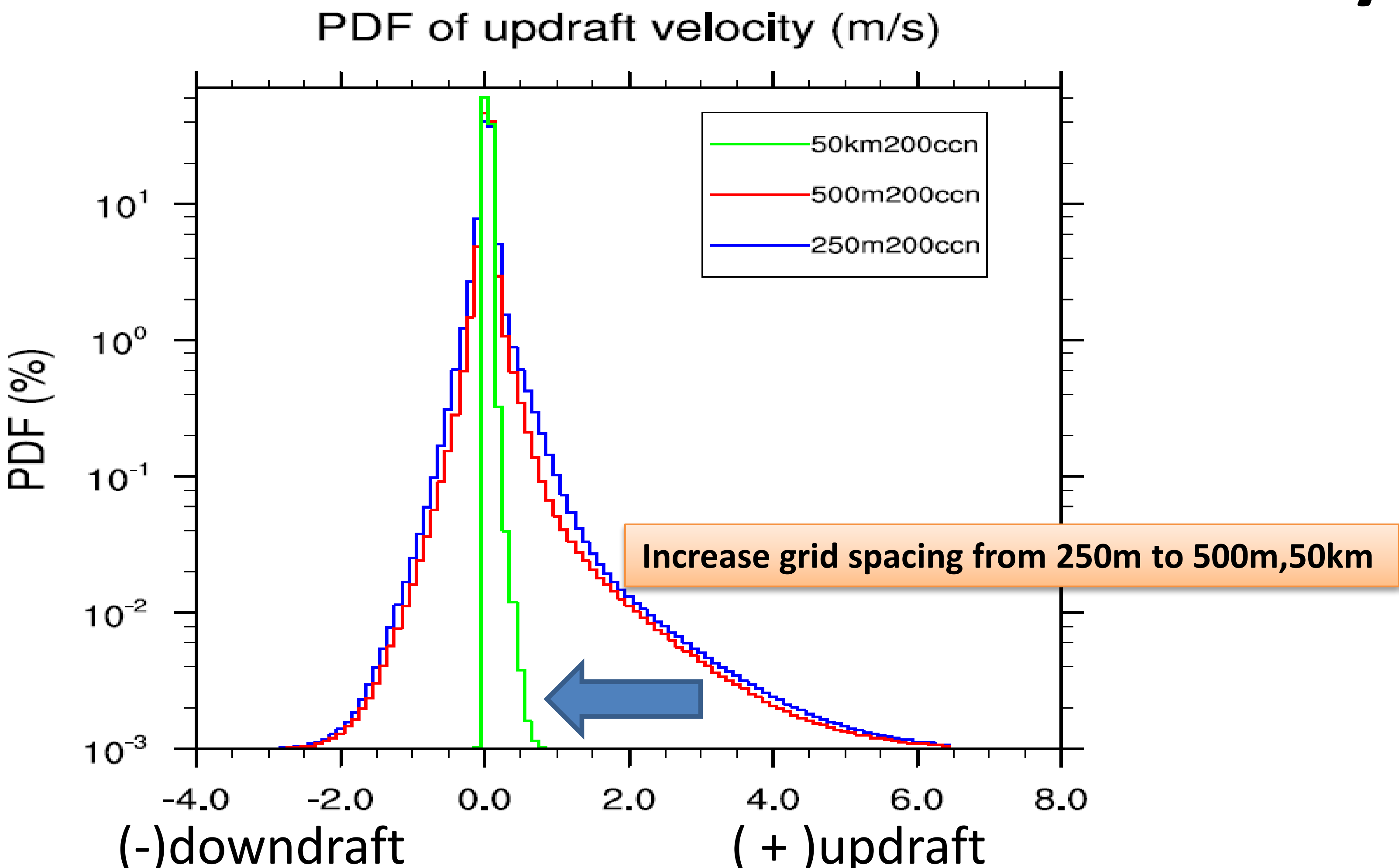


DX=50 km



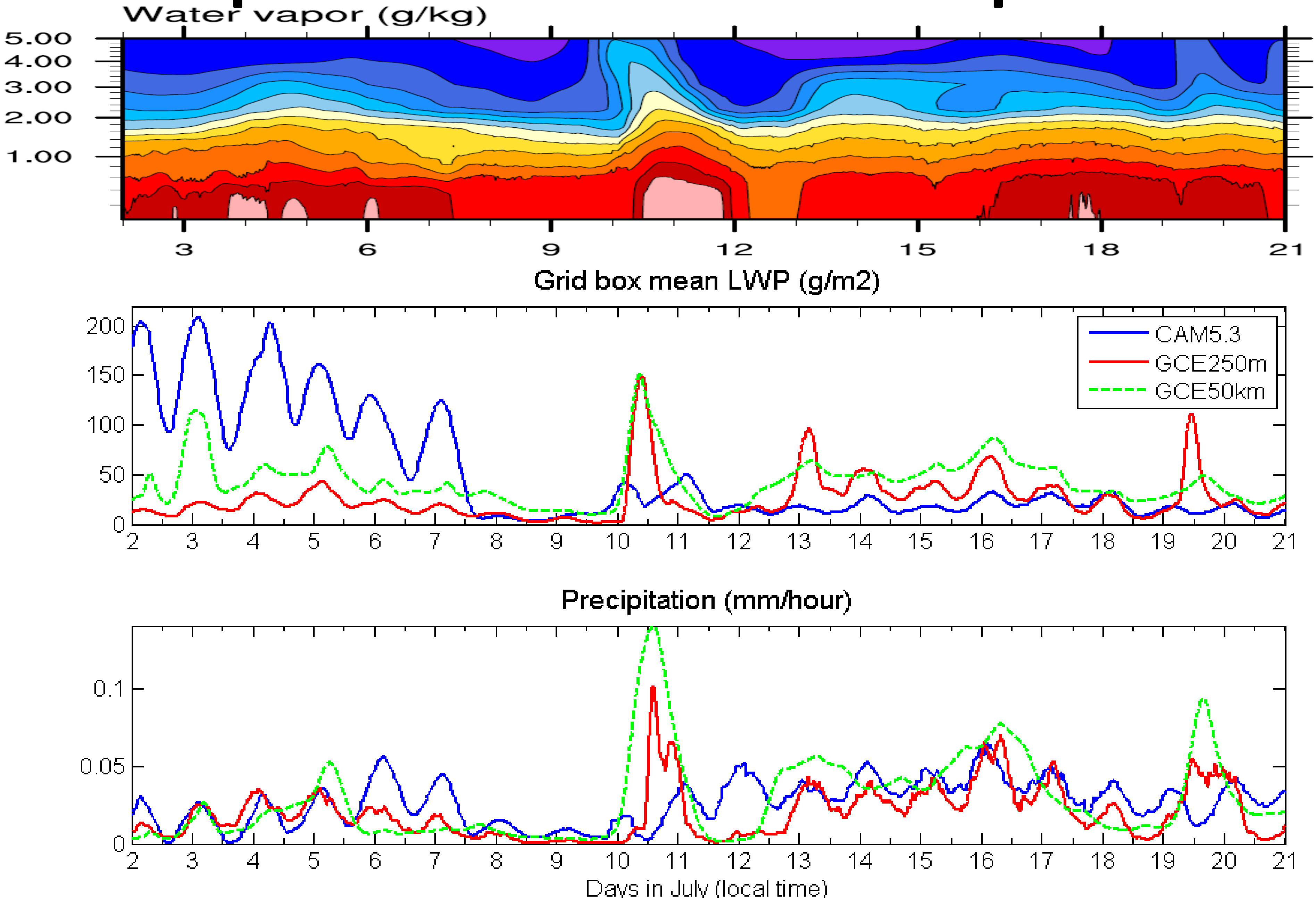
Higher resolution caused higher PBL. Why?

Effect of dx on the PDF of vertical velocity

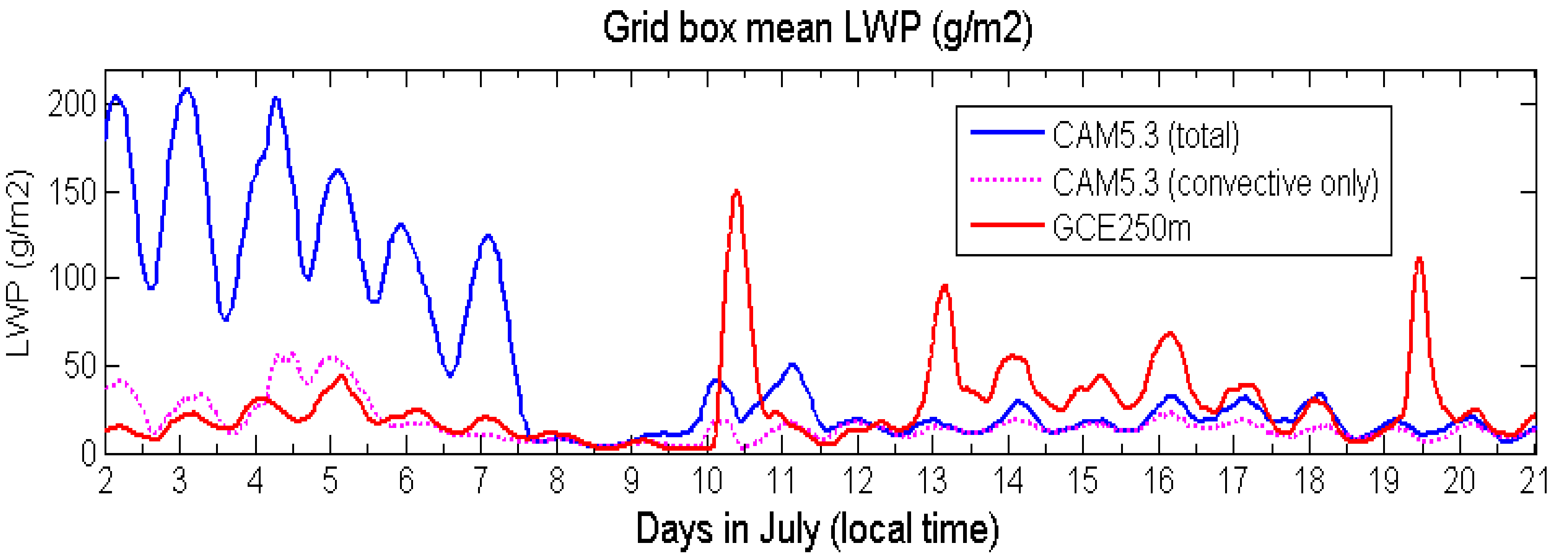


1. **Increased grid spacing decrease the strength of updrafts and downdrafts.**
2. **Mean states are closer to the GCM run with larger grid spacing**

Comparison of LWP and Precipitation



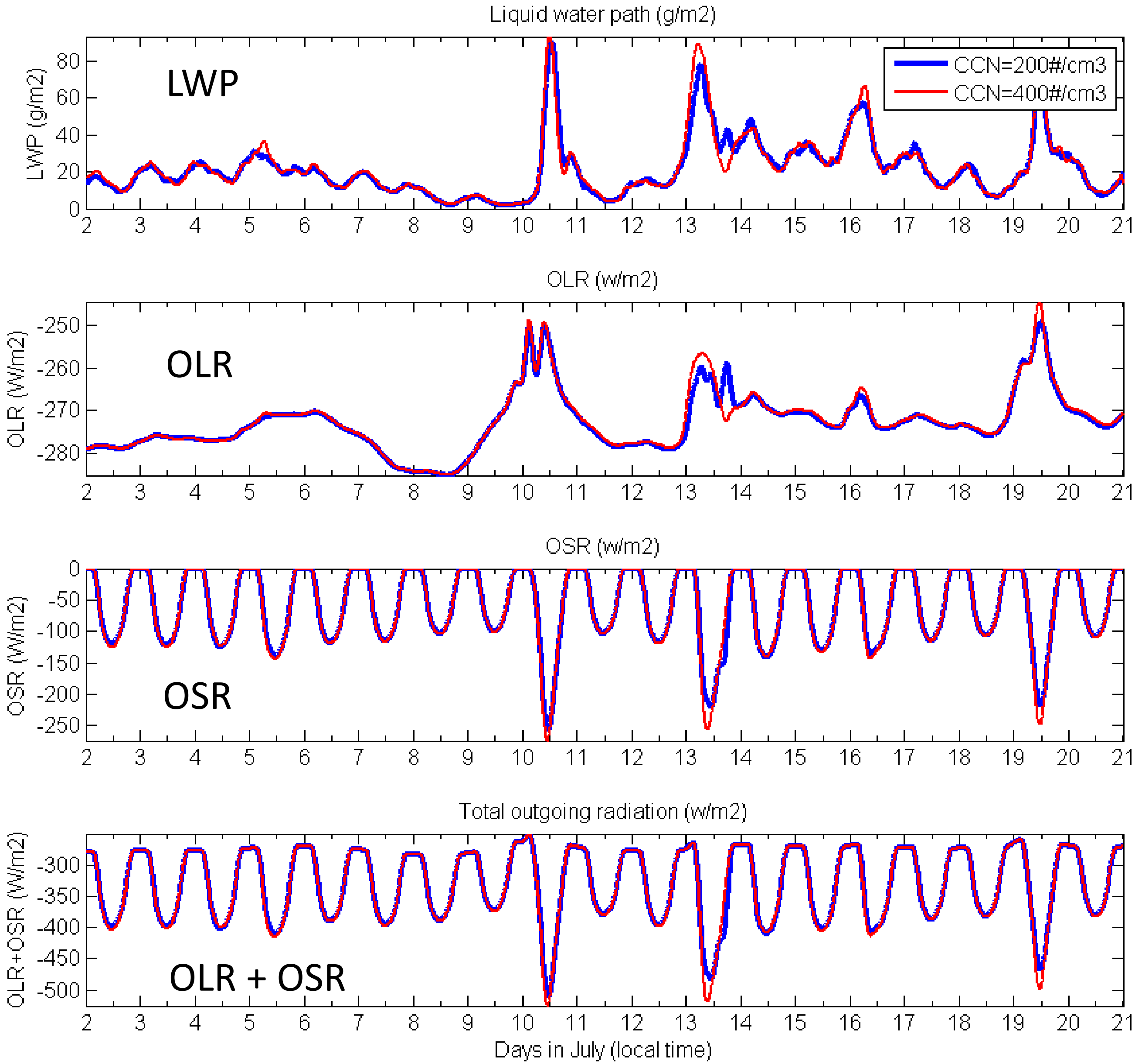
Comparison of LWP



1. If we only compare the LWP from convective clouds (pink dotted line) from CAM, two models agree better.

2. Is supersaturation removed too slowly in CAM5?

Aerosol indirect effect (doubled CCN) in the CSRM



0.36 g/m2 increase
1.76%

0.23 W/m2 decrease
0.08%, warming

1.2 W/m2 increase
2.1%, cooling

~0.97 W/m2 increase
0.3%, cooling

Doubled CCN increases LWP and has a net cooling effect for the cases studied here.

Conclusions

1. Larger grid spacing reduces the vertical motions and make CAM5 and CRM agree better.

2. CRM simulated the strong decoupled cumulus due to the advected background water vapor while CAM5 does not.

3. CAM may overestimate the non-precipitating stratus thus overestimate the LWP and aerosol indirect effect.

4. Aerosol indirect effect in the CSRM is important for the stronger convective clouds, less so on low warm clouds.

Next Step

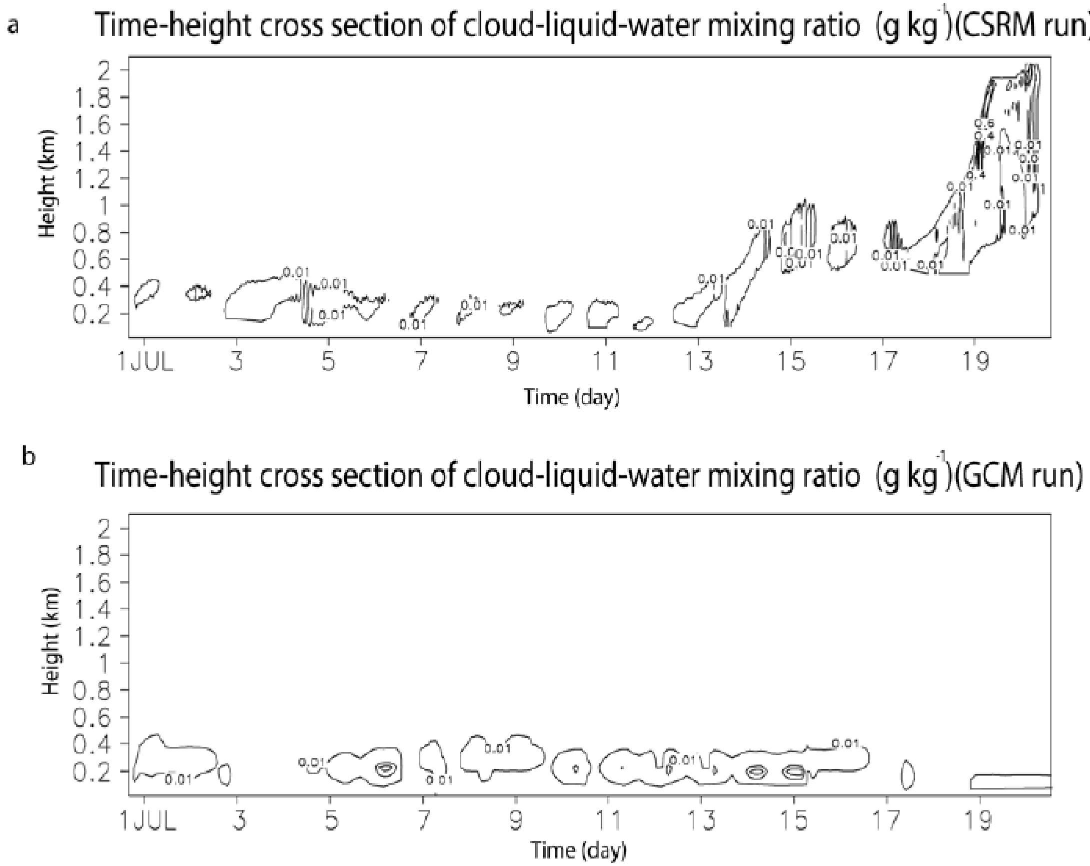
1. Use higher resolution for the CSRM model (50m).
2. Use the observed meteorological forcings and aerosol at Azores to drive CSRM.
3. Compare the modeled cloud properties to the observation.
4. Suggestion and comments?

Thank You!

Comparison of some basic features of the two models

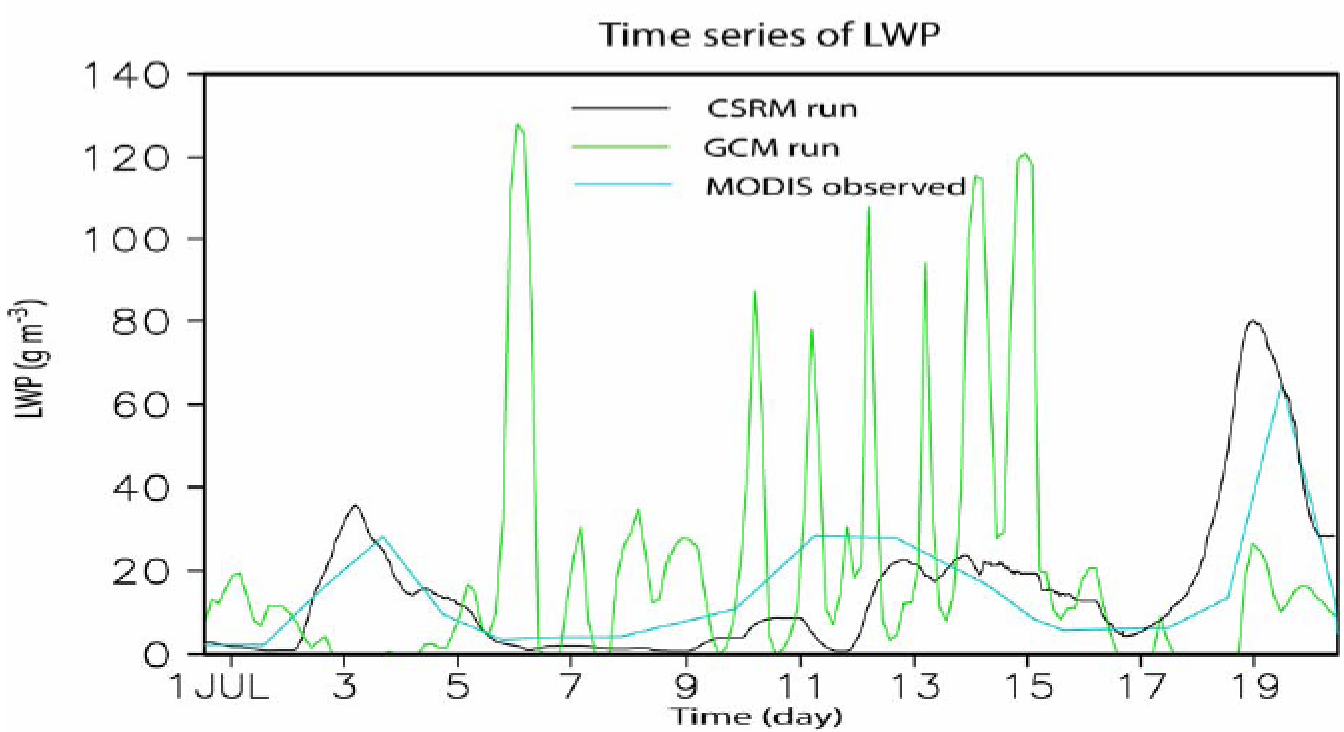
	CAM5.3	CSRM (GCE)
Horizontal resolution	~200 km	250m or 50km
Vertical resolution	~100 to 500m below 4km	~100 to 200m below 4km
Temporal resolution	Half hour	1-6 seconds
Sub-grid cloud process parameterization	• Shallow Convection Scheme (Park and Bretherton [2009]) • Deep Convection Scheme (Zhang and McFarlane [1995])	Resolved
Microphysics	• Two-momnetum scheme for ice and water (Morrison and Gettelman [2008]) • stratus only	RAMS physics, 3 species of liquid (small and large cloud droplets and rain) and 5 species of ice
Aerosol scheme	Prognostic, MAM3	Fixed CCN=200#/cm3 or 400 #/cm3 below 4km

Background: Lee et al. 2009 compared CAM3 and CSRM for thin stratocumulus clouds -1



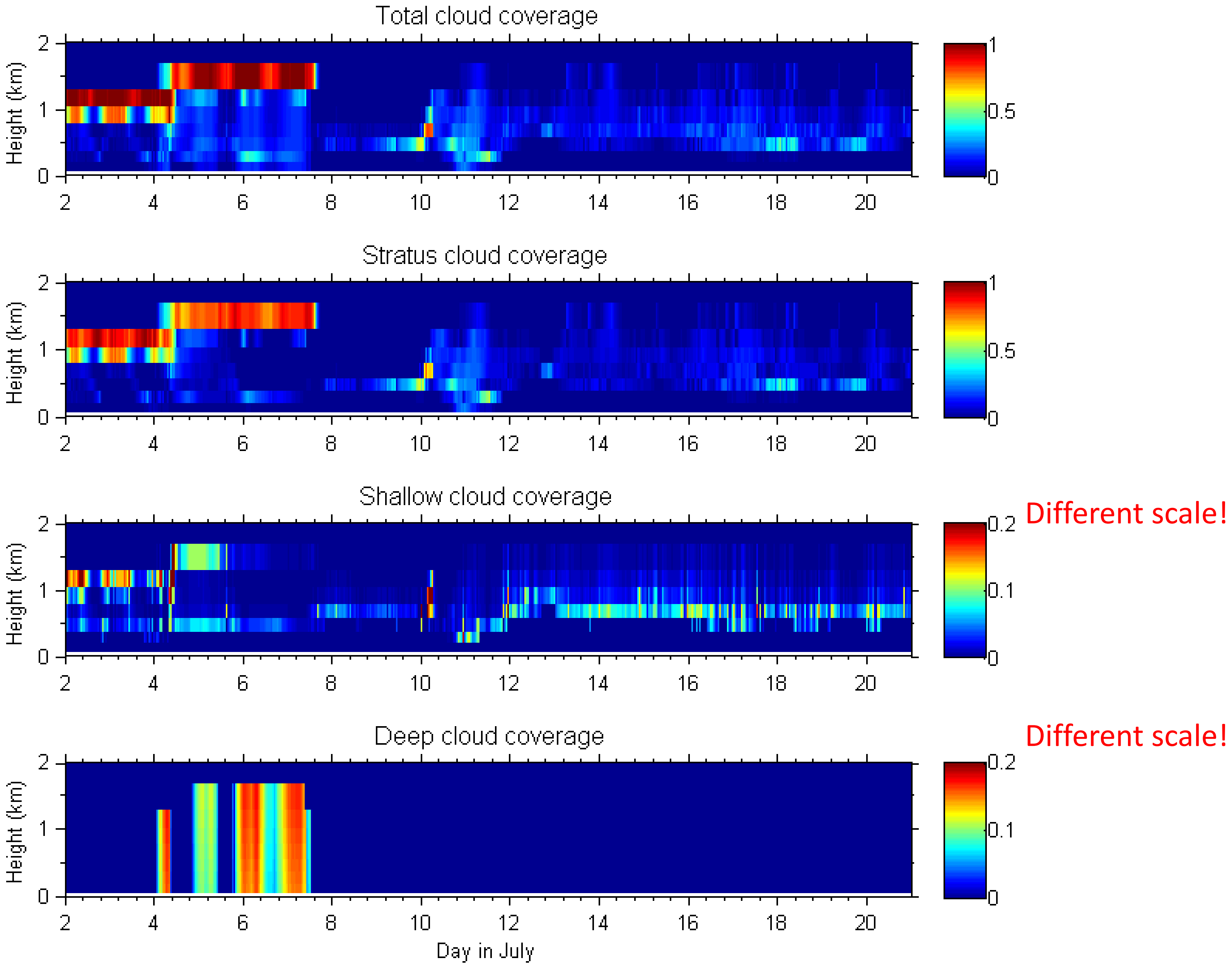
1. **CRM simulated smaller LWP before July 13th.**
2. **CRM simulated stratocumulus to cumulus transition after July 13th due to the increased surface latent heat flux.**

Background: Lee et al. 2009 compared CAM3 and CSRM for thin stratocumulus clouds -2

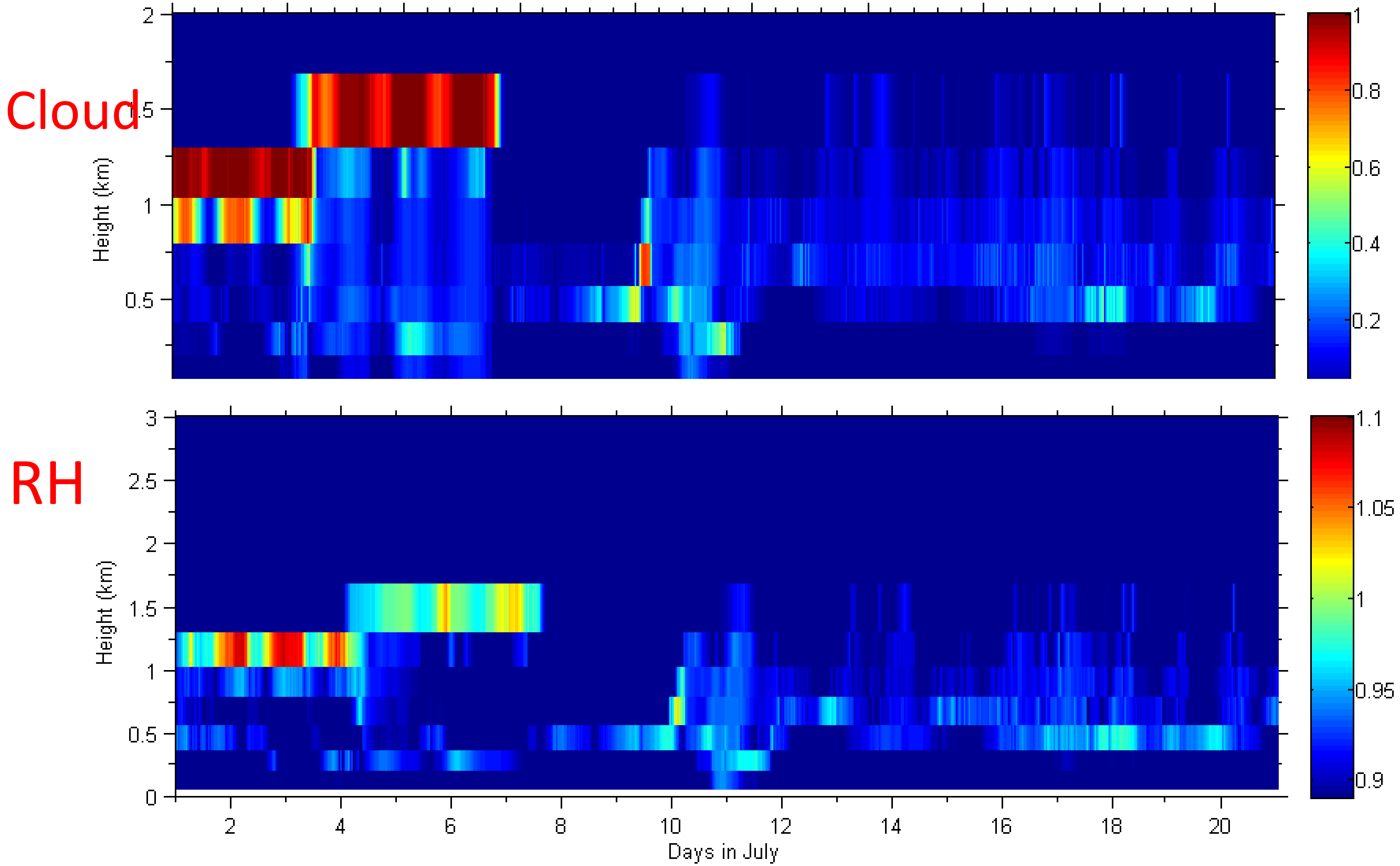


1. **CAM3 shows stronger diurnal cycle.**
2. **CRM compared better with MODIS.**

Day to day cloud fractions in July

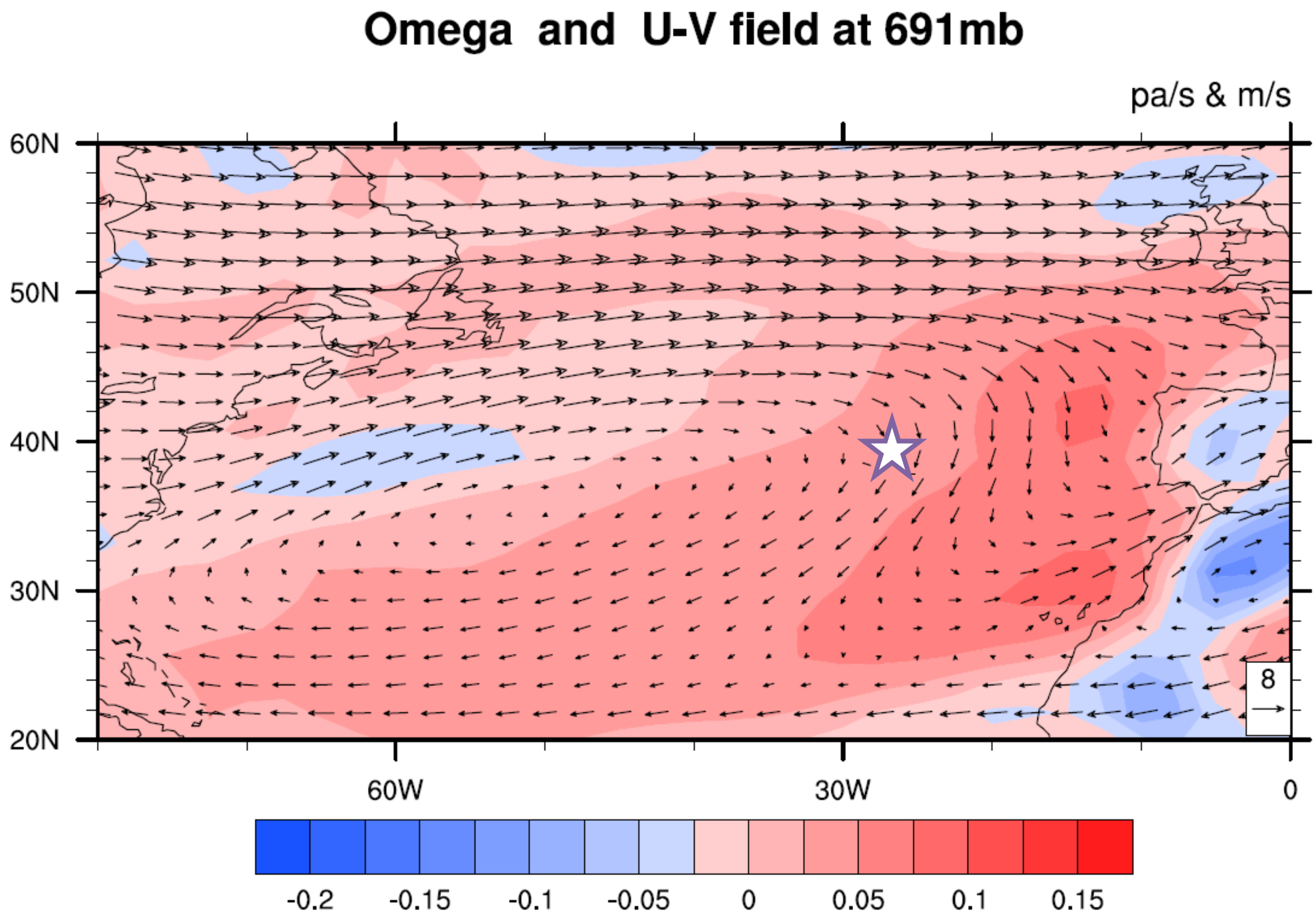


Cloud fractions and RH in CAM5



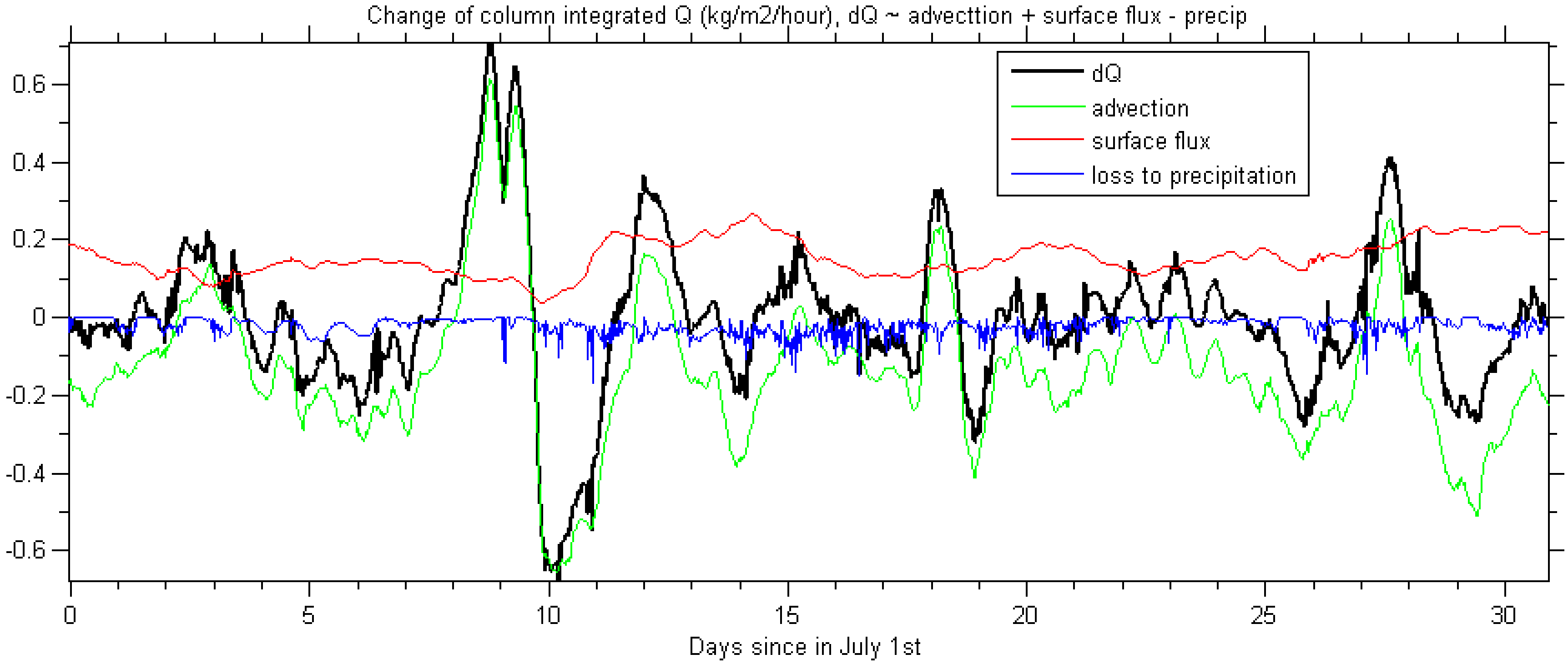
1. **Stratus cloud fraction is a function of relative humidity (both vapor and liquid).**
2. **Threshold RH is 0.89.**

Climatology at Azores: July condition

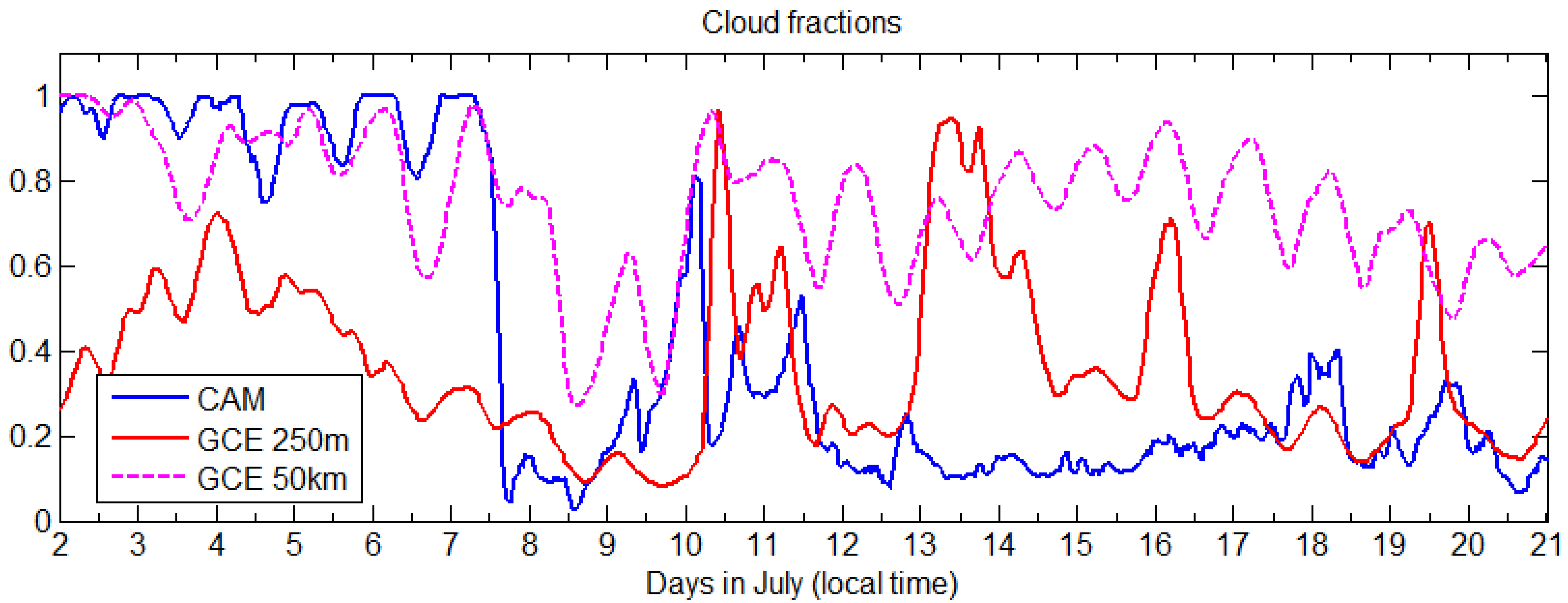


Large-scale descent controls Azores in July.

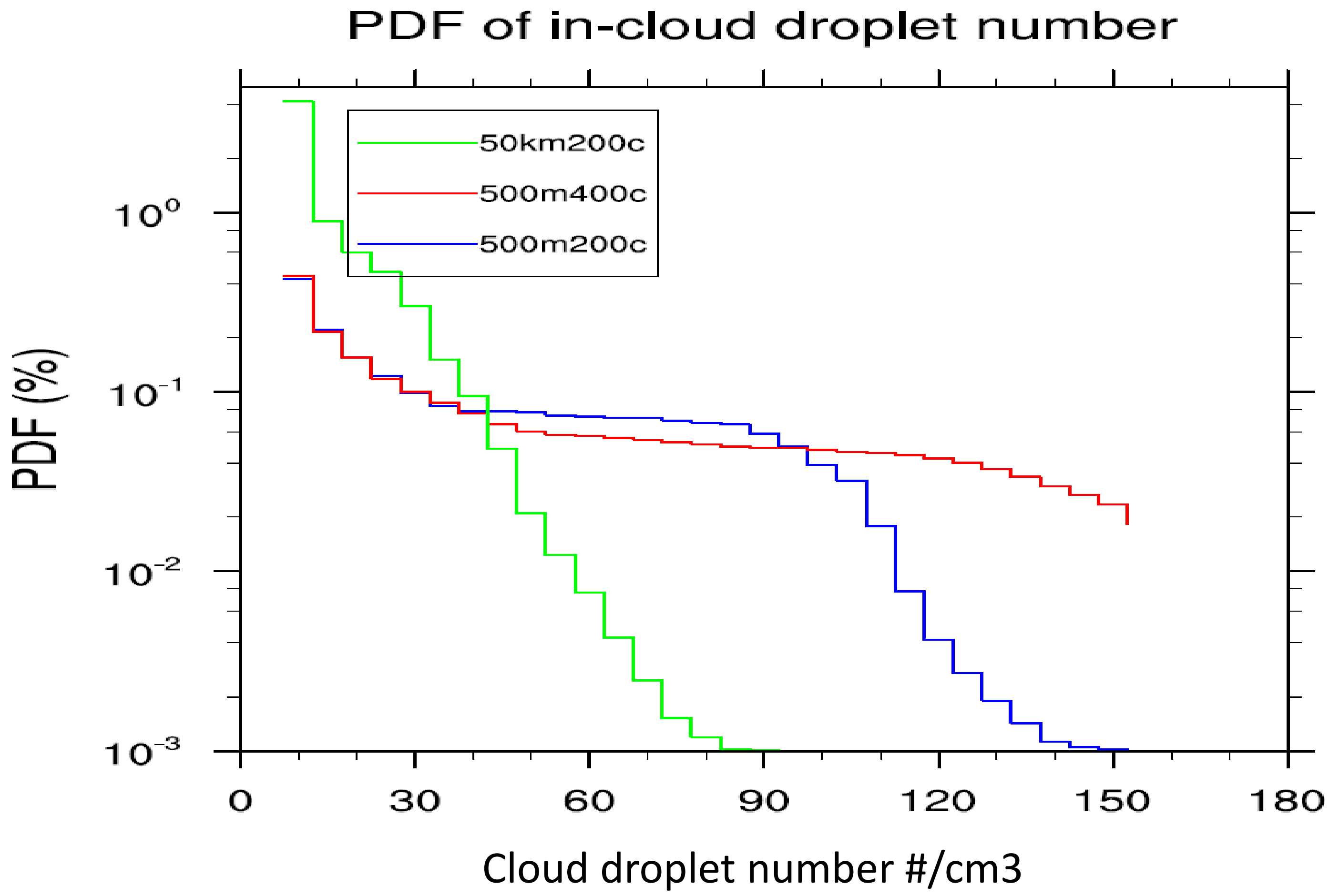
Moisture budget



Cloud fractions



In-cloud cloud droplet numbers from GCE



In-cloud cloud droplet number from CAM (stratus only)